TRANSACTIONS
AMERICAN SOCIETY OF CIVIL ENGINEERS.

INTERNATIONAL ENGINEERING CONGRESS,

1904.

Paper No. 57.

NATURAL WATERWAYS.

ROLLING DAMS.

By K. E. Hilgard, M. Am. Soc. C. E.

APPENDIX:
DISCUSSION
by the
MANAGER OF THE
GUSTAVSBURG-BRIDGEWORKS
(translated by Prof. K. E. HILGARD C. E.)

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The efforts tending toward the improvement of internal navigation and the utilization of water-power, in Germany, England and the United States, and especially in Switzerland, have offered many opportunities in recent years for the application of the Stoney type of roller sluice-gate.* Although such gates for individual openings in movable dams up to 80, 90 and even 100 ft. in width, for smaller heights, and of nearly 30 ft. in height, for smaller widths, were used successfully and are operated easily by counterbalance weights, and are proposed to be constructed of still larger dimensions in Europe as well as in the United States, a desire has frequently been felt for a device permitting the closing and opening of gaps of considerably larger proportions by means of one single body, in the shortest time possible, without requiring intermediate supports or trestle bents. The American bear-trap gate has been made to answer in some cases in the United States, as in the Chicago Drainage Canal.

*As first built by him in Ireland near Belleek and Ballinasloe, and, since then largely used on the Rivers Aare, Rhone and Rhine, in Switzerland, as well as for the regulating works on the Chicago Drainage Canal and the Sault Ste. Marie (Lake Superior) Water-Power Canal, and for many places in Great Britain and her colonies.

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TELEFONO 48-64
STUDIO TECNICO PER L'ITALIA
per impianti di traverse mobili cilindriche
SISTEMA BREVETTATO DELLE
VEREINIGTE MASCHINENFABRIK AUGSBURG und
Maschinenbaugesellschaft - NÜRNBERG, A. G.

In Germany, within the past few years, an entirely novel construction has been rapidly gaining ground, and the purpose of this paper is to describe this device and show its adaptability under varying conditions. Besides the advantage of its applicability for very large openings and for rapid operation, this new type, the "rolling dam," does not ordinarily require a separate service-bridge to connect piers and abutments and to carry operating machinery, as the Stoney gates do; and this feature alone leads to a very considerable economy in first cost.

Two such "rolling dams," of riveted-steel construction, have been built, and the great satisfaction which they have given thus far has led to the adoption and consideration of this new type of movable dam for a number of very important regulating works on various rivers in Germany and Switzerland. The first of these dams was built at Schweinfurt, Bavaria, in the "Sau" branch of the River Main, which serves as a race-way for this latter. The local difficulties to be guarded against were the floods caused by the breaking up of ice gorges. In the main river an opening of 117 ft. 8 in. in width, and in the branch named an opening of 60 ft. in width had to be provided, possibly on very short notice, and each opening had to be closed by a single shutting body.

Fig. 6 shows the location of two rolling dams. Both these openings were formerly provided in part with Poirée needle dams, but their operation proved to be too slow for such emergencies as those mentioned. For the purpose of demonstrating the serviceability of the new type of movable dam, the smaller one, in the race-way, was built first, in 1901-02, and, upon its proving a success, the larger one was built in 1903. Fig. 1, Plate XXX, is a general view of the smaller dam, and Fig. 2, Plate XXX, shows more clearly the operating mechanism. The details of the construction are shown on Plate XXXI.

At the Internal Navigation Congress, at Dusseldorf, in 1902, to which the writer was delegated by the Swiss Federal Polytechnic Institute, a complete model of the smaller of these two dams was placed on exhibition, and was explained and manipulated by its originator and patentee, Mr. Max Carstanjen.* A description of the rolling dam appeared in the reports on this Congress.† A

* Chief Engineer of the Gustavsburg bridge works, near Mainz (branch of the Vereinigte Maschinenfabrik, Augsburg, und Maschinenbaugesellschaft, Nürnberg, A. G.

† Part I, Communication No. 10.

FIG. 1.—ROLLING DAM AT SCHWEINFURT.

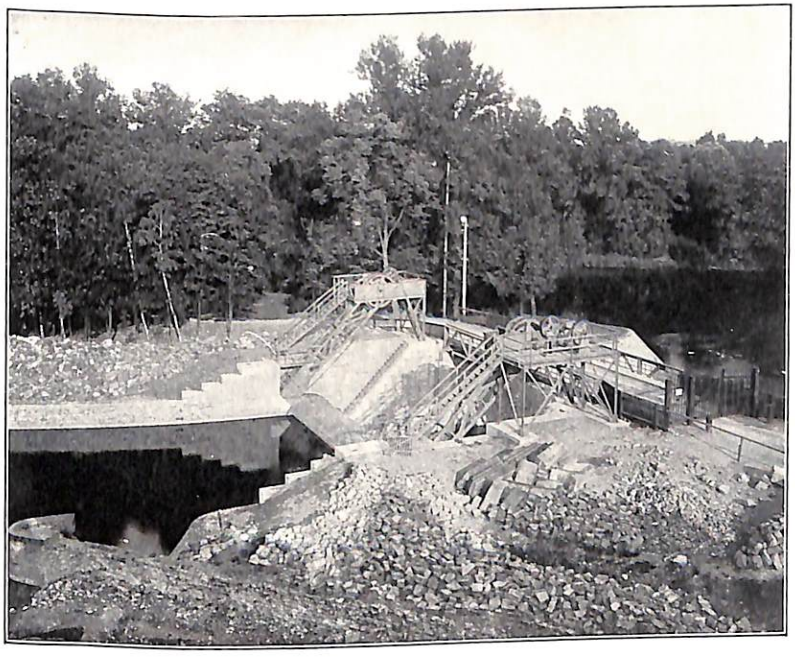

FIG. 2.—MECHANISM OF ROLLING DAM AT SCHWEINFURT.

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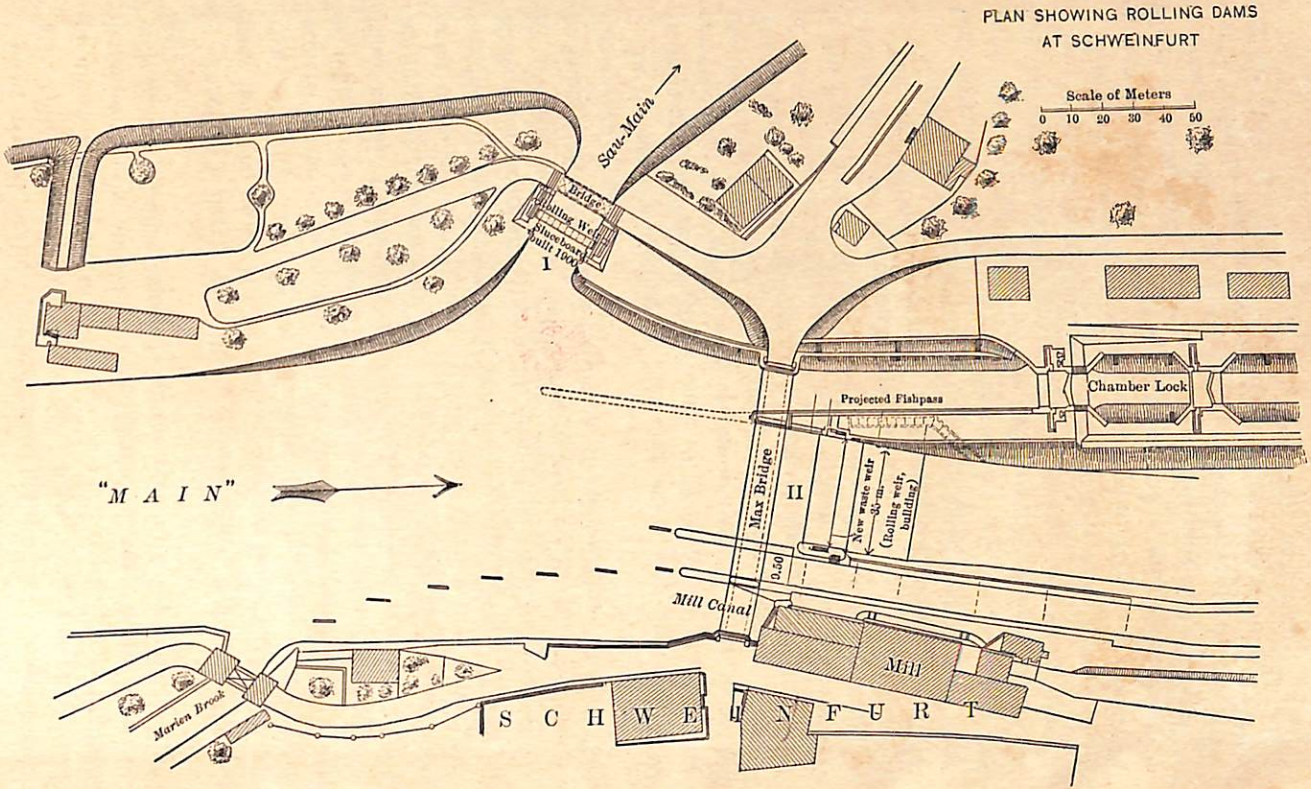

PLAN SHOWING ROLLING DAMS
AT SCHWEINFURT
Scale of Meters
0 10 20 30 40 50
Sau-Main
Bridge
Rolling Weir
Sluice-board
built Tood
I
Projected Fishpass
Chamber Lock
"MAIN"
II
Max Bridge
0.50
New waste weir
35 m.
(Rolling weir,
buttfldw.)
Mill Canal
Mill
Marien Brook
SCHWEINFURT

FIG. 6.

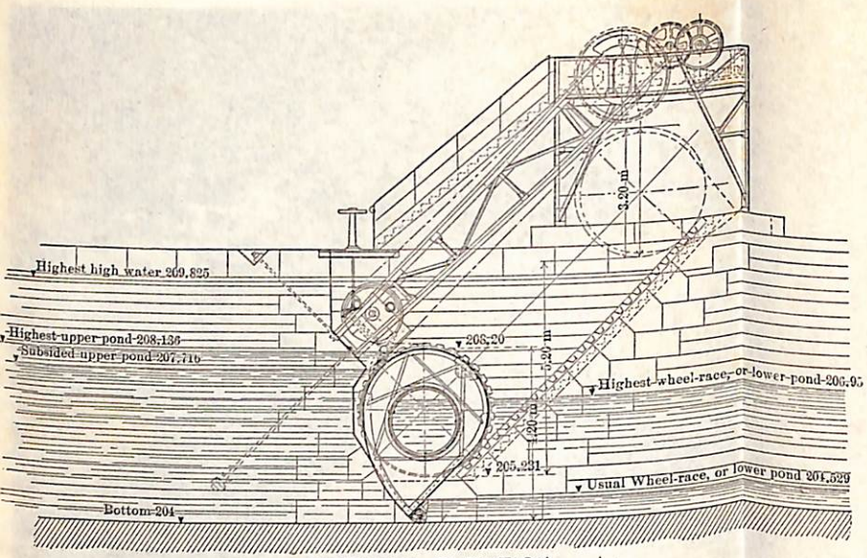
hollow, riveted, water-tight cylinder, not unlike a riveted steel-plate boiler, serves as a closure. Steel ropes, slung around the ends of the cylinder, serve to roll it up or let it down, like a barrel or large heavy tube upon an inclined plane. Large cog-wheels on the ends of the cylinder engage with the rack rails upon the inclined planes.

To effect a nearly water-tight closure with a hollow cylindrical body had been proposed previously at various times by Mr. Hirzel-Gysi, a Swiss engineer, by Baurath Hoech, formerly technical attaché of the German Legation at Washington; and also by Mr. Koechlin, a Swiss engineer in Paris; but by methods differing from those of Mr. Carstanjen, who not only proposed but carried out his original idea successfully. The writer's visit to both of these dams at Schweinfurt convinced him that there is no reason why openings of 150 ft. in width, and even more, and of a height of 30 ft., with a corresponding width, cannot be regulated successfully by a single cylindrical body; and, indeed, contracts are about to be entered into for the construction of rolling dams of the large dimensions named.

In the smaller opening at Schweinfurt, closing an opening 60 ft. wide and having a depth of water of 14 ft. in the race-way, the cross-section of the rolling body is pear-shaped, in order to reduce the buoyancy, and only at the ends is the cross-section circular. The closing, or cutting edge, as it were, of the dam, at that point of the cross-section which rests on the bottom sill in the race-way, is fitted with an oak timber, to which some pressure can be applied, whereby a satisfactorily tight contact with the sill is obtained.

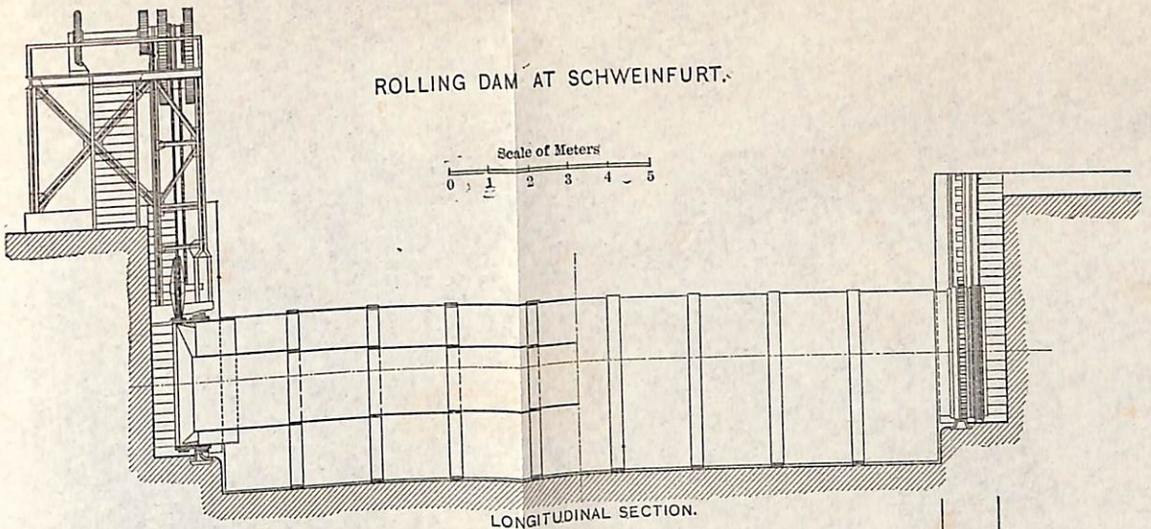
The area of the cross-section is dimensioned so that, in rolling up the dam, it always occupies the same space which the rolling body occupied previous to its motion, so that, not only no additional water has to be displaced, but the water assists the upward motion. For this same reason, no impediment to the motion, owing to sediment, debris, ice, floating bodies, or rubbish, is to be feared.

The steel ropes encircling each end of the cylinder are fastened thereto at one point, and are slung around a guide pulley and a winch drum as well. In principle the ropes may be considered as endless, but each end is wound on one of two separate drums which can be varied in their respective positions, so as to permit of taking out any slack in the rope. While, generally, only one end of the

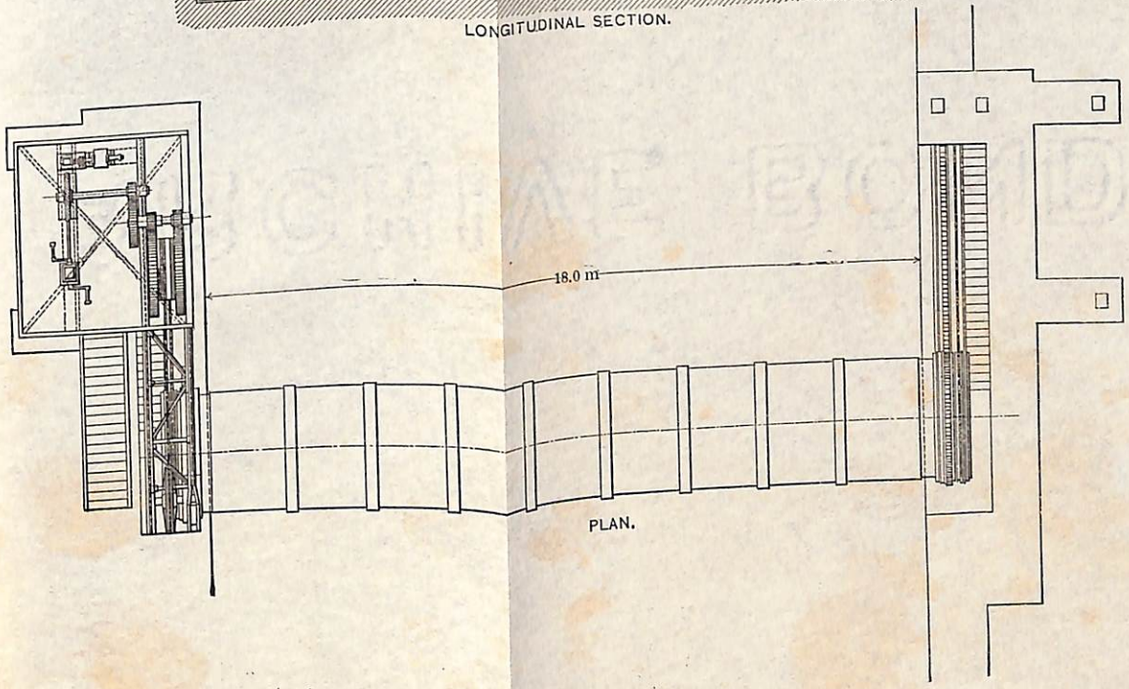


SECTIONAL ELEVATION

ROLLING DAM AT SCHWEINFURT.



LONGITUDINAL SECTION.



PLAN.

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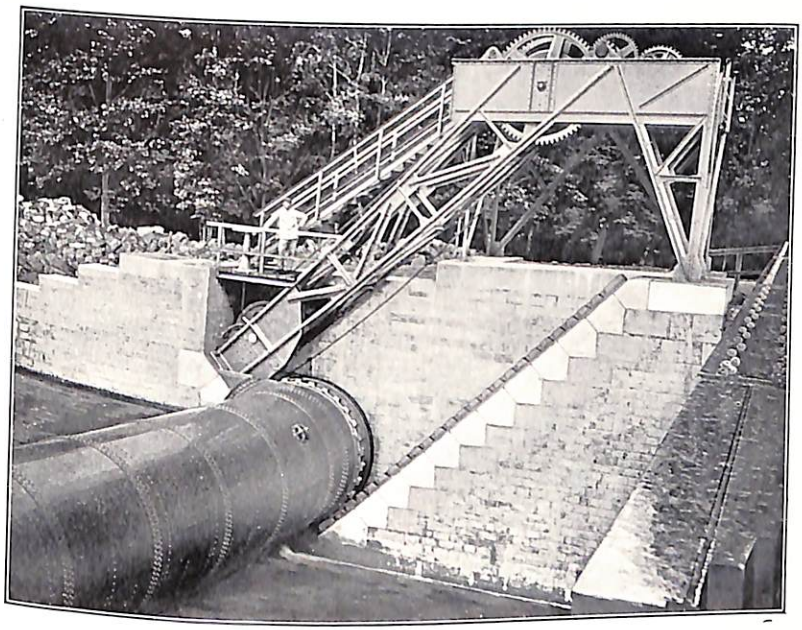


FIG. 1.—ROLLING DAM AT SCHWEINFURT.

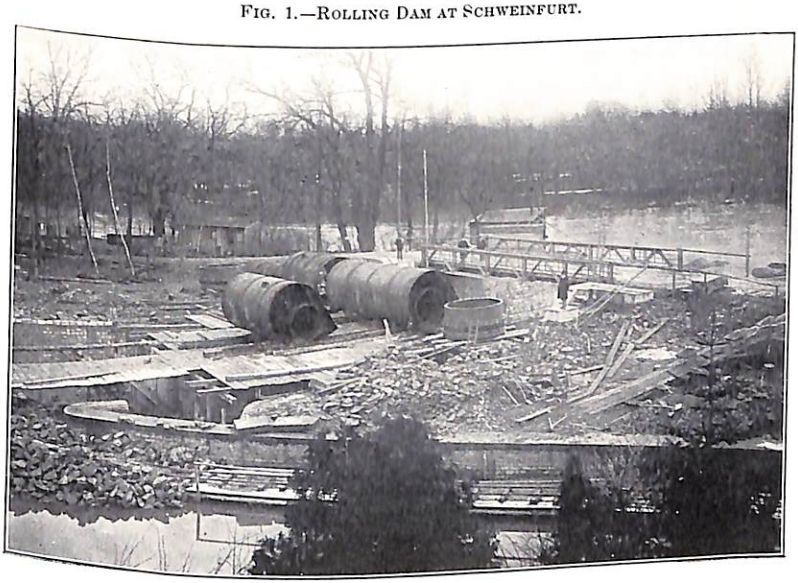


FIG. 2.—SECTIONS OF CYLINDER FOR DAM AT SCHWEINFURT.

PROVINCIA DI TORINO

rope is acted upon, *viz.*, for rolling up the dam, by action upon the other end, with a reversed motion, it is possible to exert some pressure of the cutting edge upon the sill and secure a tight fit under the dam.

By means of stops engaging at either end of the rolling dam, the cog-wheels can be locked in any position, thereby releasing the tension on the ropes. In general, debris or rubbish is not likely to lodge over the sill, because, by an approaching closure of the aperture, the velocity of the escaping water is increased so much that such bodies are carried through.

The operating machinery consists of an ordinary winch with a self-locking worm gear. The racks, cog-wheels and track are of strong construction and are designed so that any foreign bodies getting into them will drop through or can be removed easily.

The interior of the hollow drum forming the dam contains the ballast tube, of smaller diameter (see Plate XXXI), into which, being open at both ends, the back-water can enter as soon as the dam is immersed to a sufficient depth to require additional weight to overcome the buoyancy. Ordinarily, the water is never flowing over the dam. At the time of the writer's visit it was possible to walk with dry feet through the ballast tube or over the top of the cylinder. On the other hand, the water leaves the ballast tube, without causing inconvenience by its weight as soon as the dam is raised out of the water.

Besides securing a tight fit over the sill, the device for tightening the ends against the masonry is of the utmost importance. This is being done by using annular strips of leather, or can be done by using annular iron rods of circular cross-section lodged between tapering surfaces, such as are generally used with the Stoney gates.

The rolling dams have in their favor simplicity of construction, and great solidity is easily obtained. All parts which are susceptible to injury, such as steel ropes, cog-wheels, racks and stop-locks are placed within the protecting recesses of the masonry abutments; besides they are all on the side of the lower back-water, and can be either wholly protected or are subject to immersion only at rare intervals. In the Schweinfurt dams these parts are placed above the winter water-line, and, therefore, are exempt from injury or obstruction by freezing.

Inspection and maintenance are facilitated by stairways built

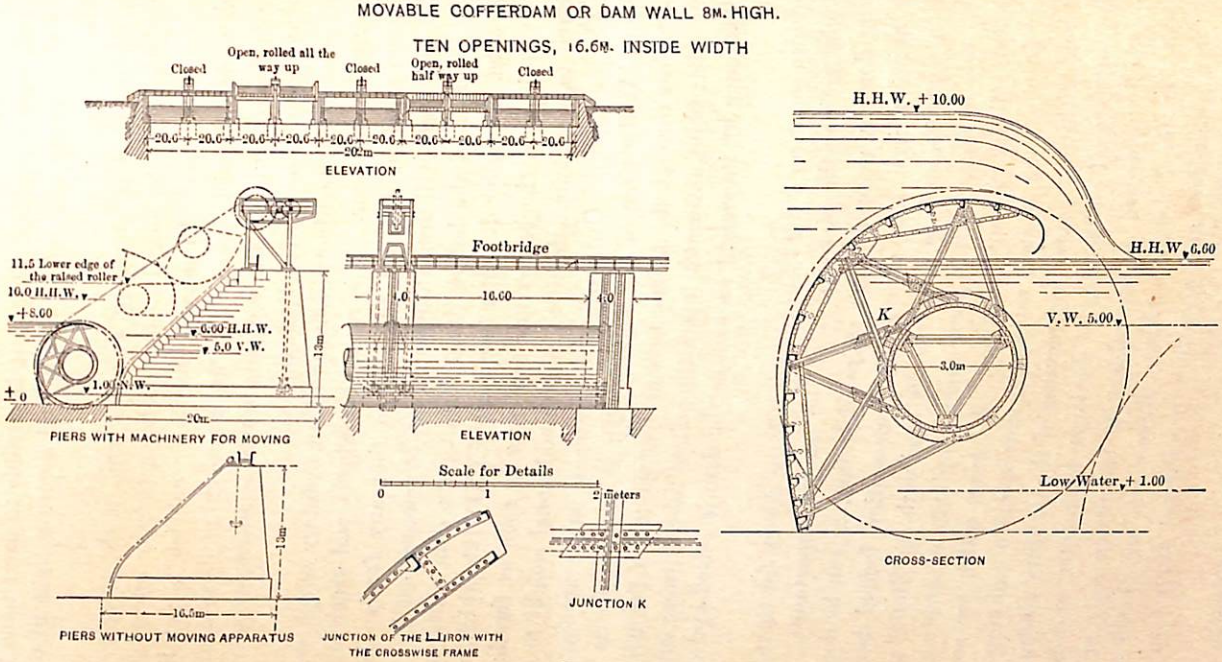

MOVABLE COFFERDAM OR DAM WALL 8M. HIGH.
TEN OPENINGS, 16.6M. INSIDE WIDTH
Closed
Open, rolled all the way up
Closed
Open, rolled half way up
Closed
20.6
202m
ELEVATION
11.5 Lower edge of the raised roller
10.0 H.H.W.
+8.60
6.60 H.H.W.
5.0 V.W.
1.0 N.W.
±0
20m
13m
PIERS WITH MACHINERY FOR MOVING
Footbridge
1.0
16.00
1.0
ELEVATION
Scale for Details
0
1
2 meters
13m
16.5m
PIERS WITHOUT MOVING APPARATUS
JUNCTION OF THE L IRON WITH THE CROSSWISE FRAME
JUNCTION K
H.H.W. +10.00
H.H.W. 6.60
K
V.W. 5.00
3.0m
Low Water +1.00
CROSS-SECTION

FIG. 7.

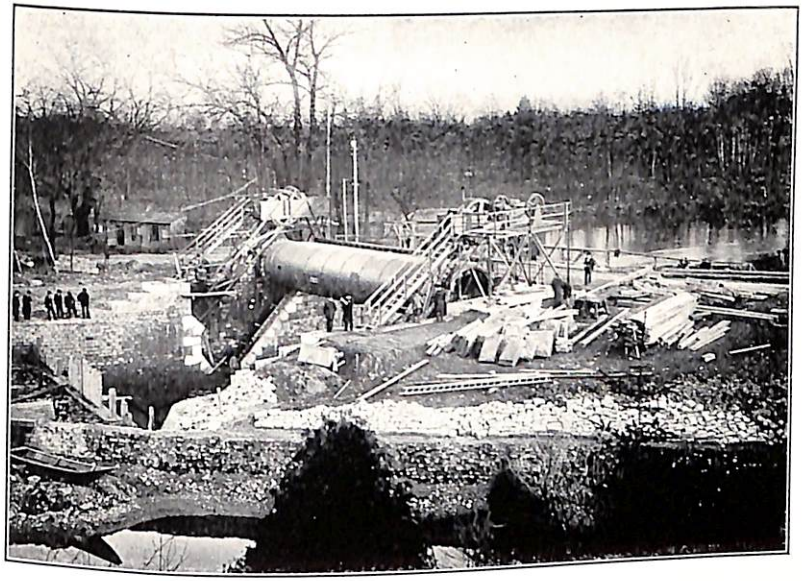


FIG. 1.—METHOD OF ERECTING THE SMALLER SCHWEINFURT DAM.

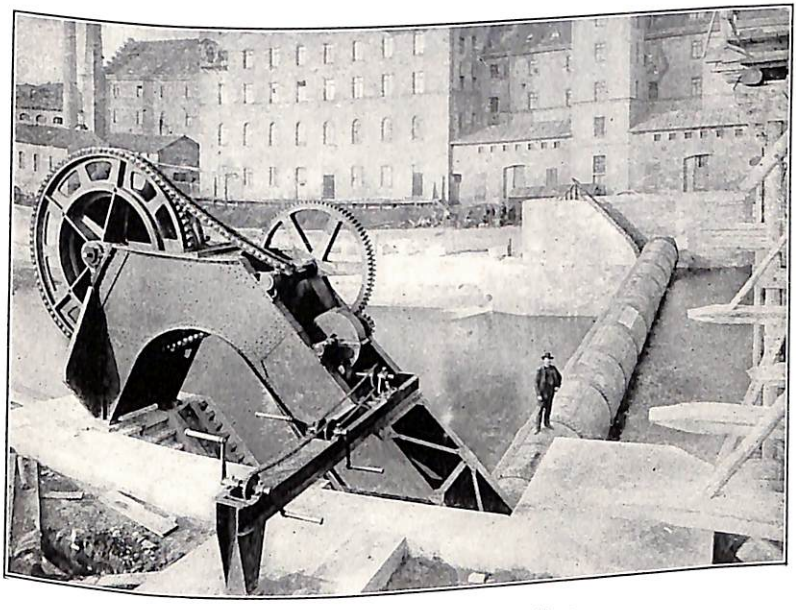


FIG. 2.—THE LARGER SCHWEINFURT DAM.

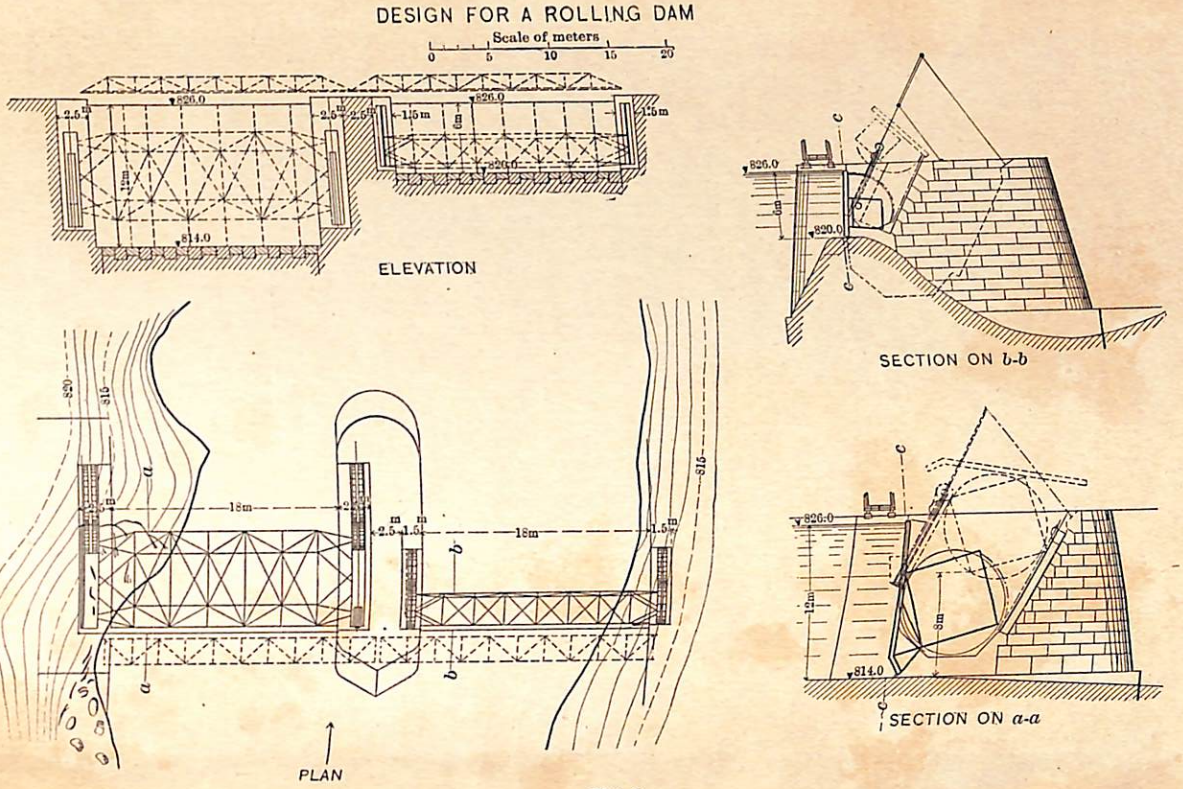

DESIGN FOR A ROLLING DAM
Scale of meters
0 5 10 15 20
826.0
2.5m
2.5m
15m
15m
12m
814.0
ELEVATION
826.0
5m
820.0
c
b
b
SECTION ON b-b
820
816
a
18m
2.5m
1.5m
18m
1.5m
b
a
PLAN
826.0
12m
9m
814.0
c
SECTION ON a-a

Fig. 8.

in the recesses of the abutments. Both dams at Schweinfurt have proved a success, but some trouble was experienced with the larger one, closing the gap of 108 ft. Its height being abnormally small in proportion to its length, and the cross-sections being circular, the dam was found to warp under the influence of heat when the sun shone on the top, and the sill had to be cambered. The dam conforms to this camber by deflection at the ends by reason of its weight.

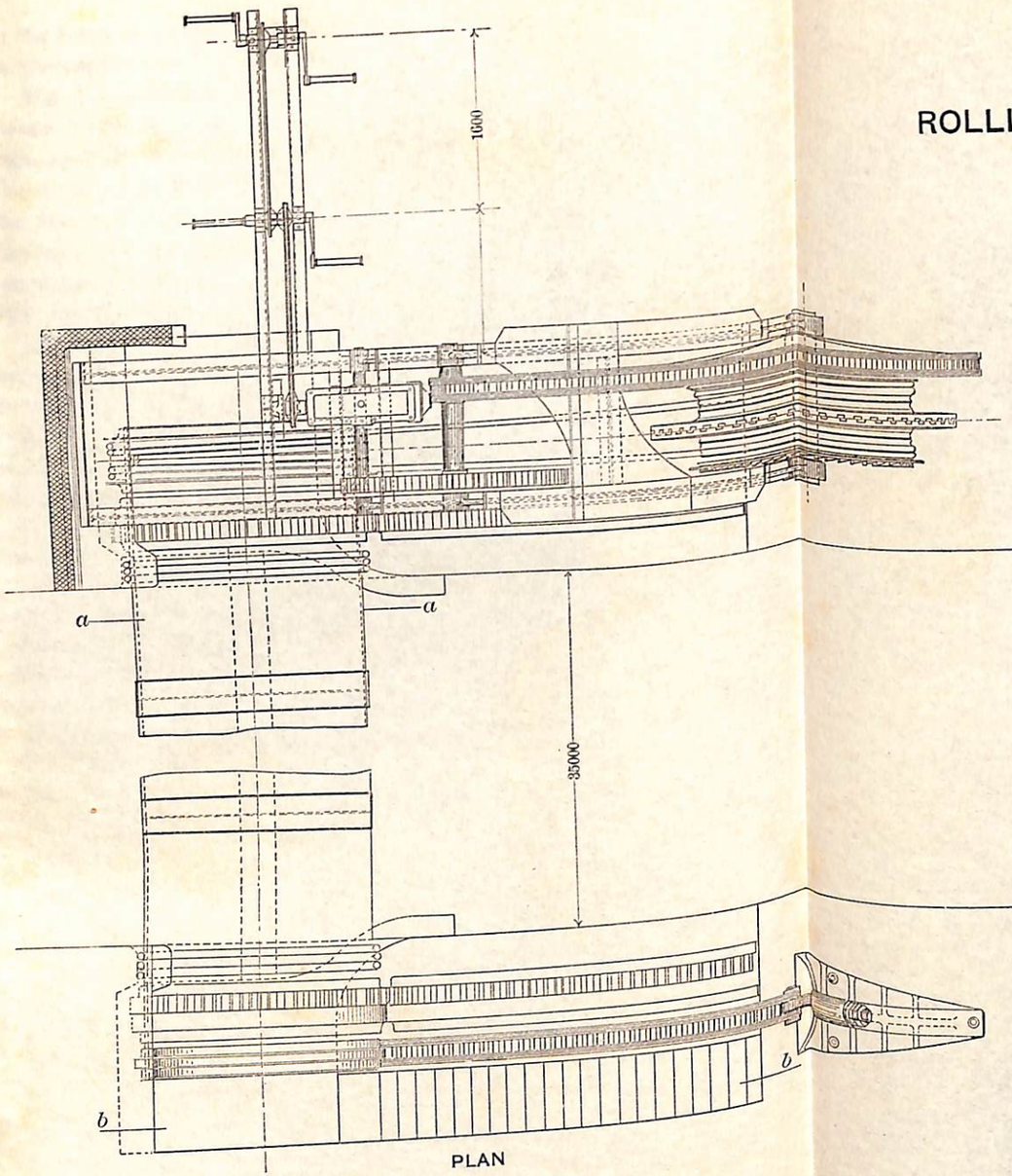
Fig. 2, Plate XXXII, and Fig. 1, Plate XXXIII, illustrate the method of erecting the smaller Schweinfurt dam. The larger dam is illustrated by Plate XXXIV. This dam has a length of 107 ft. 8 in., and a diameter equal to a depth of water of 6 ft. 8 in. It differs from the smaller dam in that it rests on a fixed masonry dam of ogee section, and is operated by machinery on one side only, although a guiding rack is provided in recesses of each abutment. The cross-section of the dam is circular. To prevent the overflow of the water from the upper side of the dam into the recesses of the masonry abutments, triangular fillets are attached to each end of the cylinder. The latter are tightened against the masonry by hemp ropes. The oak timber for the purpose of securing a tight fit over the sill is sunk into the crest of the fixed masonry dam.

On the side from which the operating machinery is omitted, a link chain is provided into which the corresponding teeth at the end of the cylinder engage to prevent any slip. In case both ends of the roller become disengaged, owing to obstructions lodging in the racks, the steel-wire rope will still prevent the dam from descending. The profile of the rack track is a cycloidal curve, compounded of portions of circles.

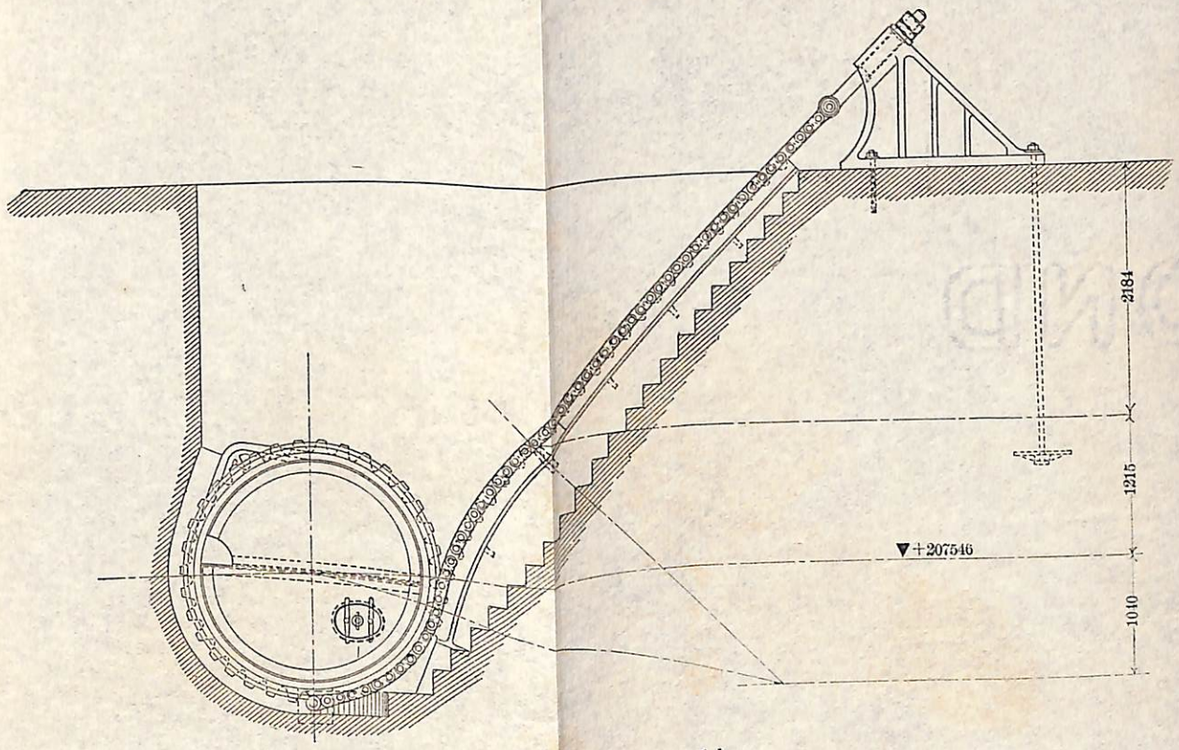
Fig. 2, Plate XXXIII, and Figs. 1 and 2, Plate XXXV, and also Plate XXXVI, show several views of this dam.

Since these two dams were built, designs differing very materially therefrom have been adopted. Fig. 7 shows a design for a rolling dam to be built in a large river of Europe, carrying large quantities of silt and debris. There are to be ten openings, each of 55 ft., the rolling dam being 27.6 ft. high, for the purpose of backing up water to that depth and still providing an overflow in case of a high stage of water amounting to 33.5 ft. in depth above the dam. The dam proper, in this case, is constructed

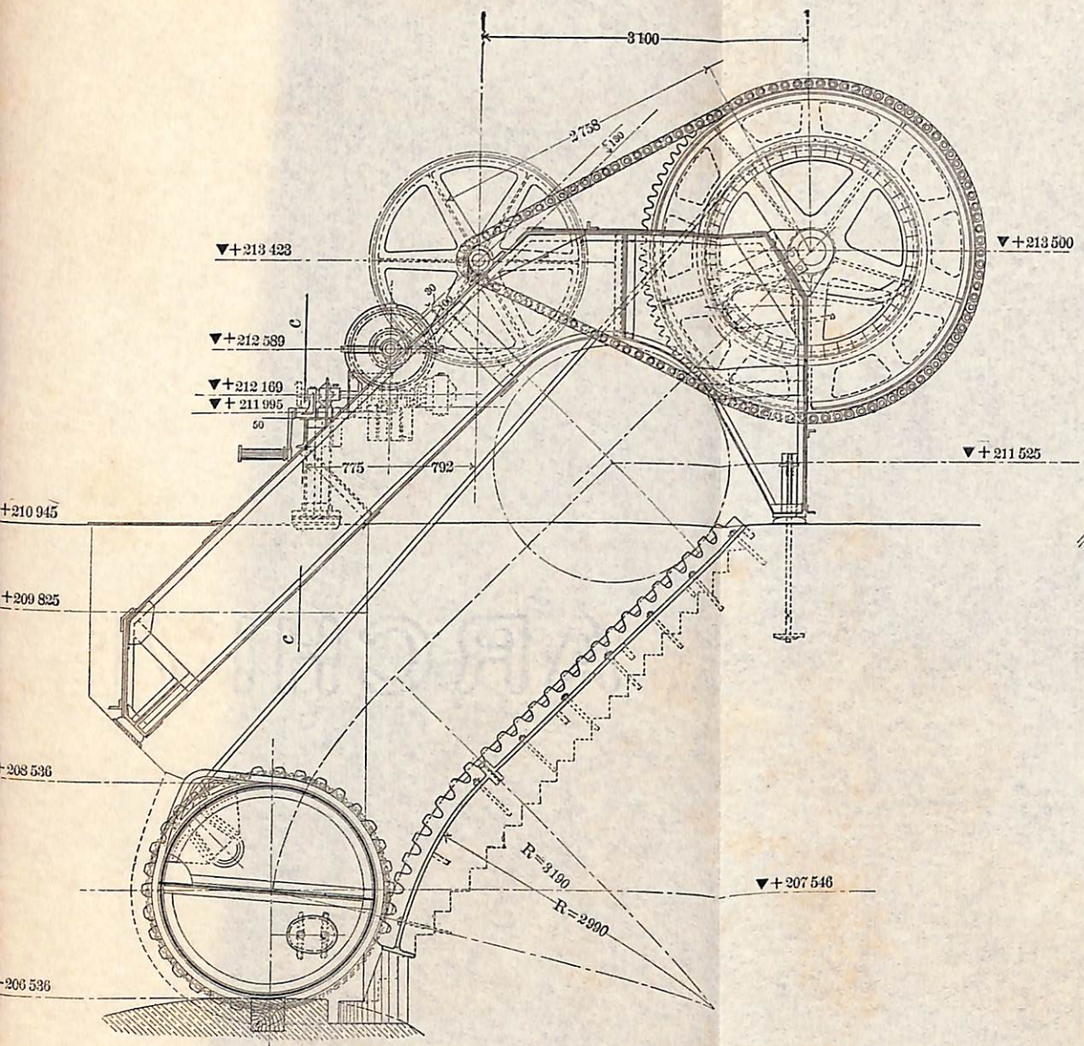
ROLLING DAM FOR THE MAIN ARM OF THE MAIN AT SCHWEINFURT



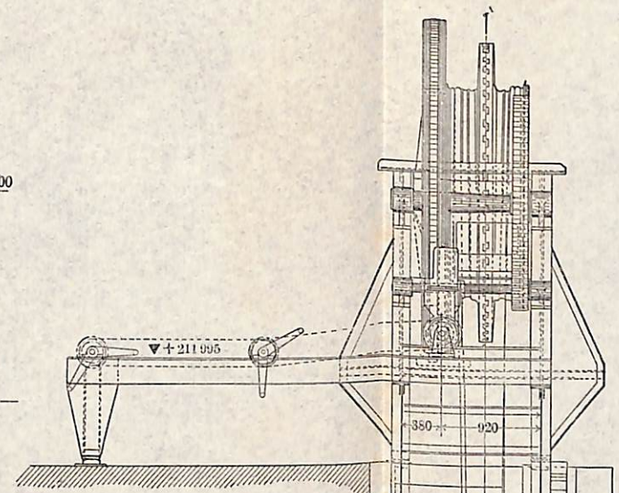
PLAN

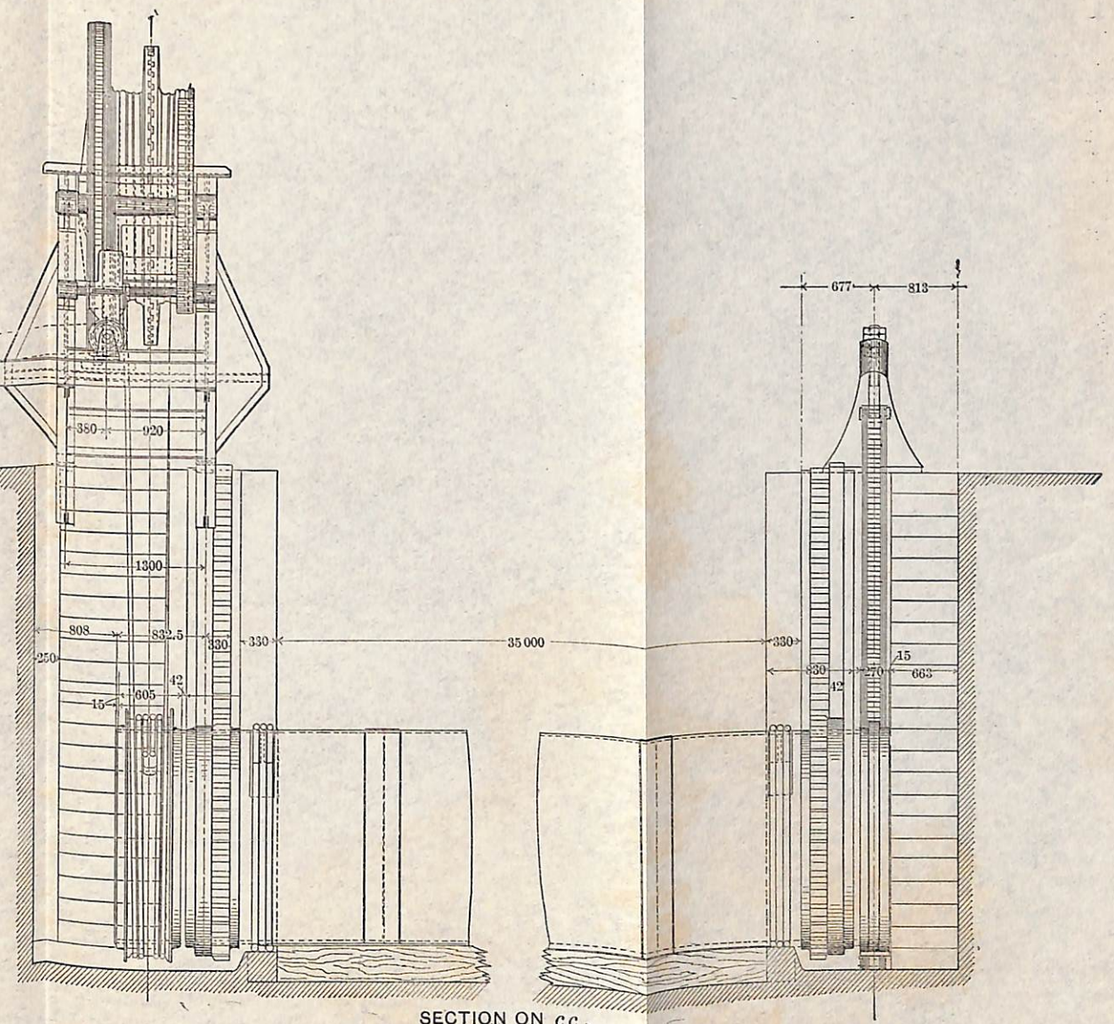


SECTION ON *bb*

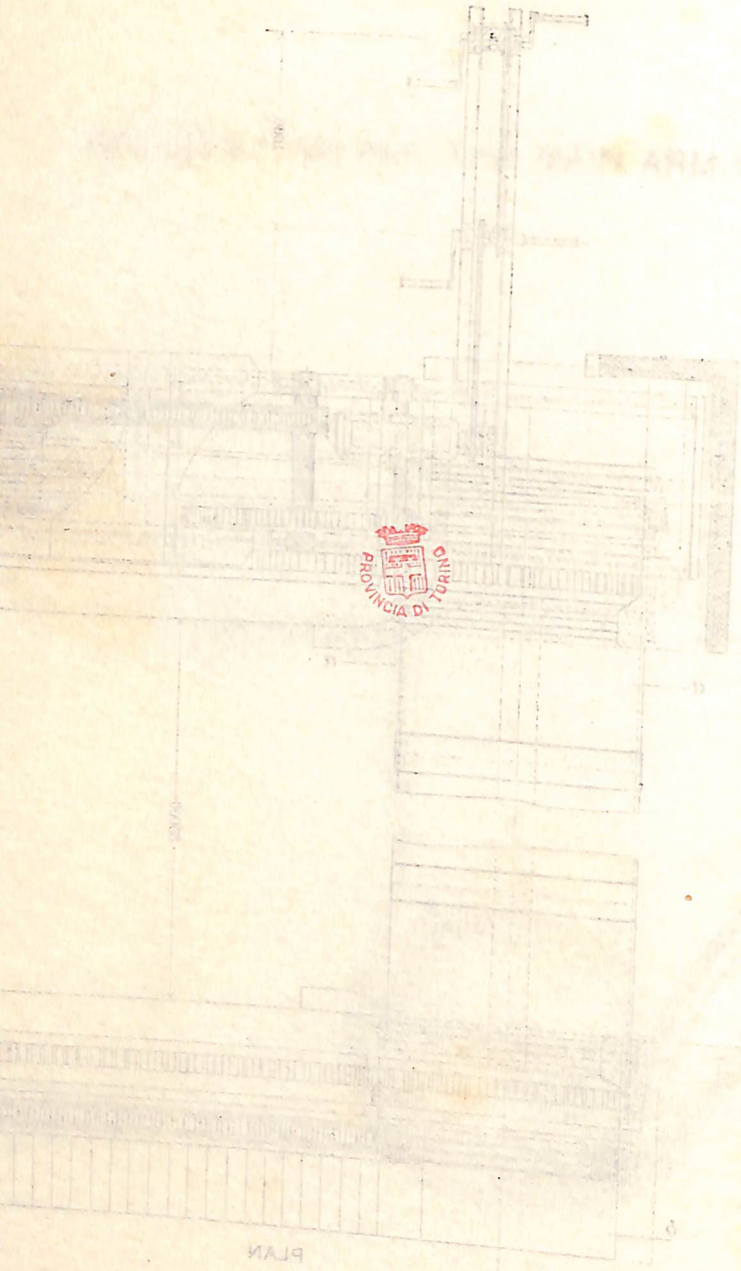


SECTION ON *aa*.





SECTION ON *cc*.


PROVINCIA DI TORINO

in the form of an apron attached to the ballast tube, and is circular in cross-section at the ends only.

Fig. 8 is a design for a dam proposed for a turbulent mountain stream which is at times heavily charged with debris. Two openings, each of 60 ft. clear opening, are provided, to back up water to elevations of 40 and 20 ft. over the sill, respectively. The body of the dam is to have a square cross-section, the up-stream face being formed by an angular or plane apron, respectively. Fig. 8 shows an elevation, a plan and cross-sections, the full lines representing the dam when closed, and the dotted lines when open.

At Schweinfurt arrangements are made for operating both dams by hand or by electrical power. Any kind of power available can be utilized. Within a year quite a number of descriptions of this new type of movable dam have appeared in various engineering journals.* It has attracted great interest among hydraulic engineers, and is destined to prove of great usefulness. In many cases it will be found to have superior advantages over other types thus far known.

The plans, photographs and much of the information from which this paper has been prepared were kindly furnished by Chief Engineer, M. Carstanjen, to whom the writer desires to express his gratitude and his hope that the new dam will meet with the success it deserves.

* *Deutsche Bauzeitung; Le Génie Civil; Zeitschrift des Oestr. Ing. und Arch. Vereines; Schweiz. Bauzeitung* (by the writer); *The Engineering Record*, and *The Scientific American.*

FIG. 1.—THE LARGER SCHWEINFURT DAM, DURING ERECTION.

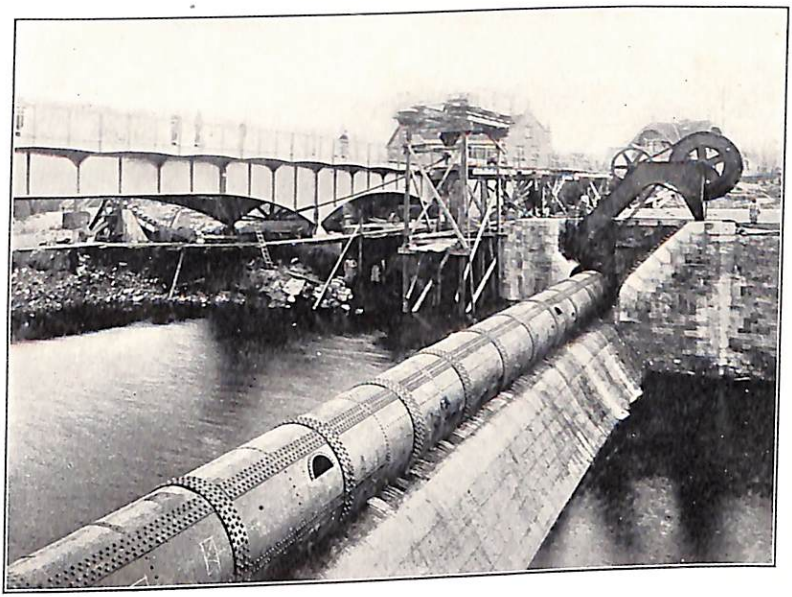


FIG. 2.—THE LARGER SCHWEINFURT DAM.

APPENDIX.

DISCUSSION

by the

MANAGER OF THE

GUSTAVSBURG-BRIDGEWORKS

(translated by Prof. K. E. HILGARD C. E.)

It gave us pleasure to be called upon by Prof. Hilgard for a discussion of his paper on: „Rolling dams". Responding to the call even if late we beg to say the following:

The requirements of a movable dam vary according to extreme stages of water, maximum flow, amount and character of debris, of drift and of ice carried by the river.

In general they are:

1. The dam when closed shall be as watertight as possible.
2. The dam when opened shall permit of an unimpeded passage of the maximum flow at flood-time, of debris, drift and ice.
3. The manipulations required for opening the dam shall neither be interfered with nor even rendered any more difficult at a high stage in the river nor by debris, drift or ice, but shall be effectible with all desirable expediency and safety.

We believe that of all types of movable dams so far known and tried, none fulfills all of these requirements to equal perfection. The nearest approach to it is obtained by the „Stoney" free roller sluice-and by the bear-trap gates.

Prof. Hilgard mentioned that the application of the Stoney sluice gate appears to be limited to certain although even

quite large dimensions and to openings between piers which might not in all cases permit of a safe and speedy passage of great floods accompanied by drift and debris or ice.

It is reported that in some of the larger Swiss installations the Stoney sluice gates, if little or half opened, when water is rushing through underneath with great velocity due to a considerable head, are being violently tossed up and dowu so as to endanger the safety of the suspender-ropes or chains and even the entire lifting mechanism regardless of selflocking worm-gears.

Beartraps possess the objectionable feature that important parts of the movable dam are permanently submerged and do not permit, with facility of either inspection or repairs.

This latter disadvantage seems to be less regarded or felt with American rivers, where conditions may differ from those on our European continent, where it is of sufficient weight as to almost preclude the application of that system of movable dams.*)

An analysis of the merits of our rolling dams will result in the following:

The requirement of a watertight closure is met almost to perfection. In the larger dam at Schweinfurt a peculiar and characteristic observation was made. The upper portion of the barrel shaped, rather slender, cylindrical dam, rising above backwater, was thus directly exposed to the rays of the sun, while its lower portion and the entire upstream side being immersed in comparatively cool water was thus protected. The cylinder being thus unevenly warmed, in consequence of longitudinal dilation of the exposed surface, warped to an even curve and to such an extent as to rise at the middle from the sill towards the sun, causing thereby a slight escape

*) Besides it is doubted whether ordinary Beartrapgates can give entire satisfaction in rivers carrying great quantities of silt or debris on account of the danger of silt deposits forming in the depressed space below the gates, causing trouble when they are to be lowered. (Addition by Prof. K. E. Hilgard. C. E.)

of water between cylinder and sill. However this difficulty was very soon overcome upon considering, that as soon as the above described action takes place, the cylinder no longer has an equal bearing over the entire length of the sill, but mainly is then supported at its ends only. As in this condition its own weight causes a downward deflection in the centre, it became only necessary to camber the sill to such an extent as the elastic deflection by weight, when the cylinder is supported at its ends only, will not counteract the upward deflection produced in the cylinder by thermic dilation of the portion exposed to the rays of the sun. In thus having determined the amount of camber required in conformity with which the sill was then changed, a watertight fit over the sill was obtained and no leakage of water has been experienced since.

The requirement of an unimpeded passage of floodwater through the open dam is equivalent with the necessity of providing large openings and usually on very short notice besides.

Prof. Hilgard has stated and emphasized with some sketches that as to width of openings, and if necessary, at the same time depth of water over the sill, if so desired, all dimensional limits so far observed in other systems of movable dams may easily be greatly surpassed. The maximum dimensions applicable can no more definitely be indicated, than it is possible to day to predict the maximum length of span of a steel bridge. It is far more a question of economics than a merely technical consideration which will set a limit. At any rate with the rolling dam it is possible to span openings as large as may be desired for an unimpeded passage of flood water, debris drift or ice, thus meeting the second of the principal general requirements enumerated above.

To no less an extent the third of these requirements is satisfied. The manner in which the rolling dam is acted upon to open or close the gap between piers or abutments

is based on the most favorable mechanical motion, in as much as very little resistance in form of rolling friction has to be overcome.

With the Stoney sluices rolling friction is to be overcome too and only. However there exists quite a difference in as much as with the rolling dam the entire body of the latter participates in the rolling motion and thus the rotating circle is very large, whereas with the sluice the rollers only rotate which are of a comparatively very small diameter. In as much as the power required for moving two rollers of equal weight and being equally loaded is inversely proportional to their respective diameters, a comparison of the two results in favor of the rolling dam.

Besides there is no absolute certainty that all the rollers of a sluice gate receive an equal share of the pressure sustained by the gate as must be assumed for their design.

For this reason an excess of load on some of the rollers and in consequence on the surface of the track and a consequent uneven wear of same, is not precluded, which, if it has occurred will but aggravate the resulting trouble.

With the rolling dam this drawback does not exist. It combines the duties of the gate and that of the rollers at the same time. It excells in simplicity the roller sluice and in that respect cannot be excelled by any other device, as the shutting body consists of just one single built piece.

The ease in moving the dam with so little exertion of power cannot be interfered with by debris nor ice. As Prof. Hilgard stated it is possible by shaping the upstream face of the cylindrical body in such a way that it will recede from any debris lodged against it thus precluding the least necessity of forcing it aside when the former is being raised from the sill.

As to the behaviour of such dams under the effects of ice during the last two winters considerable experience was gained with those at Schweinfurt.

During the not very severe frost periods it was possible to keep the river „Main“ within more than half a mile above the dam entirely free from any ice by slightly raising the dam daily once for half an hour or so. The current thus produced sufficed to break up and pass a sheet of ice of two to three inches in thickness which had formed in the pond above. In thus interfering with the formation of any heavier sheet of ice it became possible to prevent any jamming of the ice.

Of more essential importance, in this successful effect is believed to be the fact that the river increases materially in width from further up downward toward the dam, which makes it possible to get the sheet of ice actually started by creating a current which would not prove feasible if the river were growing narrower instead. It is not necessary thereby that the total width of openings in the dam in the aggregate exceed or equal that of the river above.

The principle condition however forms the possibility of manipulating the dam at all times and in this regard even during a heavy frost no trouble was experienced.

The larger (main) dam at Schweinfurt in the second year since its construction experienced two rushes of ice, both of which were of medium severity. The first took place unexpectedly during night time, while the dam was closed.

Only on the following morning a few huge chunks of ice which had lodged on top of the cylinder, and a heavy accumulation of ice which was densely packed in front of it on the upstream side indicated that large quantities of ice must have passed over the dam during the night. The latter was not damaged in the least although it must have sustained a heavy strain and many severe shocks; the dam was then raised with the greatest ease and the fact, that not until it had been lifted nearly 15 inches, before any water began to pass underneath, may indicate the density of the ice-pack. Experience develloped the fact that as had been surmised such a rolling cylinder would permit of limiting the necessity

for temporarily lowering the stage in the pool in order to pass the ice through the dam to the very least duration, which quite evidently is of the greatest importance in using the dam either for generating power or for purposes of navigation.

On our canalised rivers in Germany the necessity for lowering (opening) the almost usual type of Poirée-needle dams during winter, on account of ice forming, cripples navigation for a period of many weeks or even months. With the introduction of cylindrical rolling dams it seems likely, that this period of interrupted navigation might in the aggregate be limited to a few days.

Our needle dams being liable of having to be lowered sometimes on very short notice with the often sudden advent of the wintry season, within a long stretch of the river the necessity arrises for providing special ports of refuge for such barges or boats, as would not be able to retreat in time to the nearest regular harbour of trade. It is believed, that in the case where the navigable pools are created by means of such dams as described such additional ports of refuge may be dispensed with, in as much as then the advent of the first frost is no longer the signal for opening the dams for the entire season.

As a rule such dams would not have to be opened until the ice breaks up above points of navigation when this latter on account of the ice rush has to stop at all events.

The possibility of eliminating such special ports of refuge is a point in favor of the rolling dams as well if a comparison of cost is to be made with other types which do not offer this advantage.

In some of the latest designs for big rolling dams the main-body of the dam is provided with a separate crest which may be lowered or raised at will, without lifting the former from the sill, thus permitting to create an overflow for the passage of ice or drift without causing any undercurrent over the sill. This arrangement on account of the absence of any chains

or rackrods rising above the crest possesses a decided advantage over the so called secondary ice sluice sometimes provided in the upper portions of Stoney-gates.

Besides the possibility of raising the dam by machinery to be placed only at one side of the opening on pier instead of a service bridge is an economic feature which is still greatly enhanced in the case of several openings being spanned by a continous rolling dam extending over intermediate rest piers of lighter build in order to preclude any unfavourable proportions between the length of the rolling main body of dam and its height or diameter.

In summing up briefly the following may be claimed for the rolling dam:

1) A minimum of resistance in manipulation as a consequence of its particular feature of rolling motion, thereby insuring safety in operation still enhanced by the fact that this latter can be effected from one end of the dam.
2) Applicability for large openings and comparatively high heads or both at the same time.
3) Simplicity of the entire structure permitting of a very solid construction of its parts, resulting in simplicity of operation and reduction of maintenance and repairs.
4) Applicability in rivers carrying large quantities of silt, debris, drift and in cases where floods and the passing or even jamming of ice would render conditions severe.
5) Rendering it possible to reduce the periods of interrupted navigation or interference with utilization of power at full head and eliminating in many instances the necessity for special ports of refuge.

It is believed that these points in favor of rolling dams as described may justify their application in cases where other types of moving dams will fail to give satisfaction.

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